

anticipated by or, in the alternative, under 35 U.S.C. § 103(a) as obvious over Thess, et al., "Crystalline Ropes of Metallic Carbon Nanotubes," in Science, vol. 273, pp. 483-487, July 26, 1996 (hereinafter "Thess"). Claims 13-17, 19-25, 32, and 34 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Pradeep, et al., "A novel FeC₆₀ Adduct in the Solid State," in J. Am. Chem. Soc., **1992**, *114*, 2272-2274 (hereinafter "Pradeep").

Applicant notes that claims 18 and 26-31 are not rejected on prior art grounds and presumably, would be allowed once the 35 U.S.C. § 112 rejections are withdrawn.

These rejections are respectfully traversed in view of the following discussion.

Entry of this §1.116 Amendment is proper. Since the amendments above narrow the issues for appeal and since such features were in the claims earlier, such amendments do not raise a new issue requiring further searching and/or consideration by the Examiner. As such entry of this Amendment is believed to be proper and is earnestly solicited.

It is further noted that, notwithstanding any claim amendments made herein, Applicant's intent is to encompass equivalents of all claim elements, even if amended herein or later during prosecution.

Attached hereto is a marked-up version of the changes made to the specification and/or claims by the current Amendment. The attached page is captioned "**VERSION WITH MARKINGS TO SHOW CHANGES MADE**".

It is noted that the amendments are made only to more particularly define the invention and not for distinguishing the invention over the prior art, for narrowing the scope of the claims, or for any reason related to a statutory requirement for patentability.

I. THE CLAIMED INVENTION

Applicant's invention, as disclosed and claimed, for example by independent claim 13, and similarly by independent claims 26 and 34, is directed to a laser irradiation target. The laser irradiation target includes a fullerene and a catalyst mixed with the fullerene. (See Page 8, line 27-Page 9, line 4; Page 11, lines 23-26).

In a second embodiment, as disclosed and claimed, for example by independent claim 32, is directed to a laser irradiation target. The laser irradiation target includes a fullerene and a catalyst separately provided from the fullerene. The target forms a carbon nanotube when subjected to a laser ablation. (See Page 9, lines 5-9).

Conventional targets are graphite carbon based materials suitable for producing multi-wall carbon nanotube structures at generally high temperatures. However, such conventional targets can only be used at high temperatures and with complex equipment. (See Application, Page 1, line 25-Page 2, line 3; Page 2, lines 20-22 and 26-29; and Page 3, lines 11-30).

An aspect of this inventive combination is a target comprised of a catalyst mixed with the fullerene. This aspect permits a single wall carbon nanotube to be produced at low process temperatures using a short pulse-width laser ablation method. (See Page 1, lines 2-7; Page 4, lines 7-10; Page 5, lines 10-15; and Page 9, lines 10-16).

As a result of this inventive structure, the low process temperatures permit the use of simple production equipment while reducing manufacturing cost and maximizing the yield of the single wall nanotubes thus increasing quality of electronic circuit chips. (See Page 4, lines 7-10; Page 7, lines 26-28; Page 9, lines 10-16).

II. THE 35 USC §112, FIRST AND SECOND PARAGRAPH, REJECTIONS

a. 35 USC §112, First Paragraph Rejections

Claims 26-31 and 34 stand rejected under 35 U.S.C. §112, first paragraph, for subject matter not described in the specification. Applicant respectfully traverses these rejections.

In claim 26, “powder” is not new matter as the Specification on Page 11, lines 23-26 explicitly discloses that, “pure polycrystalline powder of C₆₀ (95 at%) and catalytic (Ni + Co) powder” Thus, Applicant has previously described this subject matter in the original specification.

In view of the foregoing, the Examiner is respectfully requested to withdraw the rejections.

B. 35 USC §112, Second Paragraph Rejections

Claims 13-32 and 34 stand rejected under 35 U.S.C. §112, second paragraph, for indefiniteness. Applicant submits that these claims are not indefinite.

First, in claims 13 and 26, Applicant has replaced “associated with” with “mixed” as the Specification on Page 11, lines 23-26 explicitly discloses that in one exemplary embodiment, “pure polycrystalline powder of C₆₀ (95 at%) and catalytic (Ni + Co) powder (5 at %) were mixed together and pressed and thereby a pellet (diameter: 1 cm, thickness: 5 mm) was prepared.” Claim 32 has been amended to recite “separately provided from” as the Specification on Page 9, lines 5-9 explicitly discloses that “while the catalysts are preferably included in the laser irradiation target 2 containing the 5-member carbon ring bonds, it is also possible to prepare another catalytic metal target separately and use the catalytic metal target and the laser irradiation target 2 containing the 5-member carbon ring bonds simultaneously.” Accordingly, the scope of the claim is believed to be clear to one of ordinary skill in the art.

Second, in claim 16, Applicant has replaced “combined” with “pressed together” as also explicitly disclosed in the original Specification on Page 11, lines 23-26.

Third, Applicant asserts that “at.” in claim 31 is well known in the art as an abbreviation for “atomic” percent. The Thess Reference at footnotes 7 and 10 also uses the same abbreviation.

Fourth, in claim 34, Applicant has deleted “with a substantially curved surface” to overcome this rejection.

C. 37 CFR 1.75(c) OBJECTION

Claims 14, 21, 22, 24 and 25 stand rejected under 37 CFR 1.75(c) as being of improper dependent form for failing to further limit the subject matter of a previous claim.

In response, Applicant has amended claims 14, 21 and 22. Claim 14 is amended to include “a fullerene powder.” Claim 21 is amended to include a “Ni catalyst.” Claim 22 is amended to include a “Co catalyst.” Accordingly, these claims further limit claim 13.

Applicant traverses the rejections to claims 24 and 25. Applicant asserts that to one of ordinary skill in the art “low temperature” laser ablation is “500⁰C or lower” and, preferably, “400⁰C” in accordance with the specification, page 9, lines 10-16. Similarly, Applicant also asserts that to one of ordinary skill in the art “a short pulse-width” laser ablation is “8 ns” in accordance with the specification, page 11, lines 19-20.

In view of the foregoing, the Examiner is respectfully requested to withdraw these rejections.

III. THE PRIOR ART REJECTIONS

A. The 35 USC § 102(b) and § 103 Rejection Based on Thess, et al.

Applicant respectfully traverses the assertion in the Office Action that Thess, et al. (“Thess”) teaches the claimed invention. Applicant submits, however, that there are elements of the claimed invention which are neither taught nor suggested by Thess.

As noted above, the inventive laser irradiation target includes a fullerene and a catalyst mixed with the fullerene. (See Page 8, line 27-Page 9, line 4; Page 11, lines 23-26).

In contrast, Thess only recites laser vaporization of a graphite-nickel-cobalt mixture at 1200°C to produce single-wall nanotubes. (See Thess at Abstract, Page 483, i.e., page 1). In particular, “samples were prepared by laser vaporization of graphite rods doped with 1.2 at.% of a 50/50 mixture of Co and Ni powder (~1 micrometer particle size) at 1200°C in flowing argon at 500 Torr, followed by heat treatment in vacuum at 1000°C to sublime out C₆₀ and other small fullerenes. (See Thess, Page 487, i.e., Page 6, Column 1, References and Notes Section, Note Number 7).

Accordingly, Applicant traverses the assertion in the Office Action that “the fourth page 5-member carbon rings, such as metallated C60, also taught are nanotubes.” (See Office Action at Page 3). As indicated, Thess uses a graphite-nickel-cobalt mixture as the target where the reactant graphite material is not disclosed as being a fullerene. Thus, Thess discloses a catalyst without a fullerene. Therefore, nickel-cobalt is in a mixture with the graphite not a target, including fullerene, as disclosed in Applicant’s invention.

The claimed invention, on the other hand, includes a fullerene and a catalyst as the target unlike Thess. In particular, the claimed laser irradiation target includes a fullerene and a catalyst where the catalyst is mixed with the fullerene. (See Page 8, line 27-Page 9, line 4;

Page 11, lines 23-26). As a result, a significant advantage of using a fullerene and a catalyst mixed with the fullerene is that Applicant's invention produces single wall carbon nanotube at low process temperatures, e.g., for exemplary purposes only in a range of 350-450°C, using a short pulse-width laser ablation method. (See Page 1, lines 2-7; Page 4, lines 7-10; Page 5, lines 10-15; Page 9, lines 10-16). Thus, in Thess, C₆₀, is the primary product of the above reaction but where SWNTs are also produced as a by product of the same reaction based on a target with a different composition than Applicant's invention. In contrast, and for emphasis, Applicant's target includes fullerenes as an initial reactant mixed with a catalyst to produce single wall carbon nanotubes as the primary product as disclosed in Applicant's invention. However, Applicant's invention, includes a catalyst mixed with a fullerene, and thus it is not necessary that the mixture be used as a laser irradiation target.

For emphasis, Thess clearly fails to disclose, teach or suggest a fullerene, let alone, a catalyst mixed with a fullerene as recited in claim 13. Thess also clearly fails to disclose, teach or suggest a fullerene, let alone, a catalyst separately provided from the fullerene, for example, as cited in claim 32. Rather, the Thess invention discloses a structurally different reaction target as discussed above for use at much higher process temperature. In particular, as with Thess, "when graphite/metal materials are used for the laser irradiation target in the pulsed laser ablation, a high temperature process of 1100°C or higher becomes necessary. Yield decreases rapidly if the temperature becomes lower than 850°C, and the formation of bundles of the single-wall carbon nanotubes becomes impossible below 600°C." (See Application, Background Section, Page 1, lines 25-Page 2, lines 3). Accordingly, it would at least be necessary, but possibly not sufficient, to modify the Thess material to a fullerene, change the catalyst to a single element mixed with the fullerene to attempt reproducing

Applicant's invention, i.e., the target. Consequently, the Thess conventional structure is also unsuitable for achieving at least two objects of the invention, which include producing a single wall carbon nanotube at low process temperatures using a short pulse-width laser ablation method. Thus, Applicant's target combined with the low process temperatures permit the use of simple production equipment while reducing manufacturing cost and maximizing the yield of the single wall nanotubes and increasing the quality of electronic circuit chips (See Page 1, lines 2-7; Page 4, lines 7-10; Page 5, lines 10-15; Page 7, lines 26-28; and Page 9, lines 10-16).

For at least the reasons outlined above, Applicant respectfully submits that Thess does not disclose, teach or suggest all the features of claims 13, 32, and 34, and related dependent claims. Accordingly, Thess does not anticipate or render obvious the subject matter of claims 13, 32, and 34. Withdrawal of the rejection of claims 13-25, 32, and 34 as anticipated by Thess is respectfully requested.

Finally, for the above cited reasons, regarding the dependent claims which depend from claim 13, 32 and 34, these claims are patentable not only by virtue of its dependency from the independent claim but also by the additional limitations they recite.

For the reasons stated above, the claimed invention is fully patentable over the cited reference.

B. The 35 USC § 102(b) Rejection Based on Pradeep, et al.

Applicant respectfully traverses the assertion in the Office Action that Pradeep, et al. ("Pradeep") teaches the claimed invention and, in particular, "Ni-C₆₀ and Ni(C₆₀)₂. Ni is a catalyst. The intended use, target, does not limit the product claimed." (See Office Action at Page 3). Applicant submits, however, that there are elements of the claimed invention which

are neither taught nor suggested by Pradeep.

As noted above, the inventive laser irradiation target includes a fullerene and a catalyst mixed with the fullerene as recited in claims 13 and 34. Similarly, as recited in claim 32, the target includes a fullerene and a catalyst separately provided from the fullerene.

First, the inventive target in which the fullerene and catalyst are “mixed” is very different than the NiC_{60} and $\text{Ni}(\text{C}_{60})_2$ disclosed by Pradeep. A “mixture” is defined as “a heterogeneous association of substances that cannot be represented by a chemical formula.” (See Hawley’s Condensed Chemical Dictionary, Richard J. Lewis, Sr., Thirteenth Edition, 1997, Page 757, definition of “mixture”). Accordingly, Applicant’s target is a “mixture” as it cannot be represented by a chemical formula as opposed to Pradeep’s NiC_{60} and $\text{Ni}(\text{C}_{60})_2$.

In contrast, Pradeep only recites an FeC_{60} adduct, i.e., a non-mixture, in the solid state including formation of “an FeC_{60} complex in the gas phase by means of a ligand-exchange reaction and have also characterized NiC_{60} and $\text{Ni}(\text{C}_{60})_2$ in the gas phase.” The Fe adduct of C_{60} was produced through “contact-arc vaporization of graphite in an atmosphere of $\text{Fe}(\text{CO})_5$.” (See Pradeep, 1st Paragraph, lines 7-10; and 2nd Paragraph, lines 1-3).

NiC_{60} and $\text{Ni}(\text{C}_{60})_2$ are coordination compounds formed from the ligand-exchange reaction where the Ni like Fe is “inside the cage of C_{60} .” (See Pradeep, 6th Paragraph, lines 3-6). It is well known to one of ordinary skill in the art that a coordination compound is “formed by the union of a metal ion (usually a transition metal) with a non-metallic ion or molecule called a ligand or complexing agent.” “The most common metal ions are those of cobalt, platinum, iron, copper, and nickel, which form highly stable compounds.” (See Hawley’s Condensed Chemical Dictionary, Richard J. Lewis, Sr., Thirteenth Edition, 1997, Page 296, definition of “coordination compound,” and Page 670, definition of “ligand.”). As

indicated, this coordination compound is a stable product formed from the reaction of Ni and C₆₀, which can be represented by a chemical formula, whereas Applicant discloses a catalyst mixed with a fullerene which can not be represented by a chemical formula. Thus, Pradeep does not disclose, teach or suggest a “mixture,” let alone, a catalyst mixed with the fullerene or, alternatively, a catalyst separately provided from the fullerene. (Page 8, line 27-Page 9, line 4; Page 11, lines 23-26).

For at least the reasons outlined above, Applicant respectfully submits that Pradeep fails to teach or suggest all of the features of independent claims 13, 32 and 34, and related dependent claims.

Regarding dependent claims, which depends respectively from claim 13, 32 and 34, these claims are patentable not only virtue of their dependency from their respective independent claim, but also by the additional limitations they recite.

For the reasons stated above, the claimed invention is fully patentable over the cited reference.

IV. FORMAL MATTERS AND CONCLUSION

In view of the foregoing, Applicant submits that claims 13-21, 23-34, all the claims presently pending in the application, are patentably distinct over the prior art of record and are in condition for allowance. The Examiner is respectfully requested to pass the above application to issue at the earliest possible time.

Should the Examiner find the application to be other than in condition for allowance, the Examiner is requested to contact the undersigned at the local telephone number listed below to discuss any other changes deemed necessary in a telephonic or personal interview.

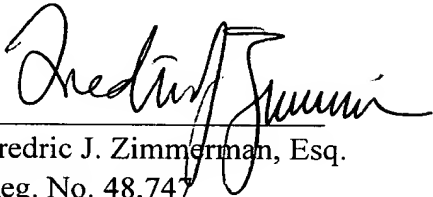
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13

The Commissioner is hereby authorized to charge any deficiency in fees or to credit any overpayment in fees to Attorney's Deposit Account No. 50-0481.

Respectfully Submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the claims:

Claim 22 is canceled without prejudice or disclaimer.

The Claims were amended as follows:

13. (Amended) A laser irradiation target for the manufacture of carbon nanotubes by laser ablation, said target comprising:

a fullerene; and

a catalyst [associated] mixed with said fullerene.

14. (Amended) The laser irradiation target as claimed in claim 13, wherein said fullerene comprises [a five-membered carbon ring] a fullerene powder.

16. (Amended) The laser irradiation target as claimed in claim 13, wherein said catalyst [is [combined with] and said fullerene are pressed together.

18. (Amended) The laser irradiation target as claimed in claim 17, wherein said laser irradiation target comprises between 4.5 at. % and 5.5 at. % catalyst.

20. (Amended) The laser irradiation target as claimed in claim 13, wherein said laser irradiation target comprises about 5 at. % catalyst [is separately provided with said fullerene].

21. (Amended) The laser irradiation target as claimed in claim 13, wherein said [fullerene] catalyst comprises [a plurality of five-membered carbon rings and a plurality of six membered

carbon rings] a Ni catalyst.

22. (Amended) The laser irradiation target as claimed in claim 13, wherein said [fullerene] catalyst comprises a [six-membered carbon ring] Co catalyst.

26. (Amended) A laser irradiation target for the manufacture of carbon nanotubes by laser ablation, said target comprising:

a fullerene powder; and

a catalyst powder [associated] mixed with said fullerene powder.

27. (Amended) The laser irradiation target as claimed in claim 26, wherein said catalyst powder [is mixed together with] and said fullerene powder are pressed together.

31. (Amended) The laser irradiation target as claimed in claim 26, wherein said laser irradiation target comprises 5 at. % catalyst powder.

32. (Amended) A laser irradiation target comprising:

a fullerene; and

a catalyst [associated with] separately provided from said fullerene,

wherein said target forms a carbon nanotube when subjected to a laser ablation.

34. (Amended) A laser irradiation target, comprising:

a [non-graphite] three dimensional structure of carbon atoms having a plurality of 5-

member[ed] carbon rings and a substantially hollow truncated-icosahedron geometric shape
[with a substantially curved surface]; and
a catalyst mixed with said three dimensional structure.